In 1997, fewer than half of all respondents—45 percent—selected teaching as their primary work responsibility, a decline from 63 percent in 1973. While some of this decline is driven by the increasing number of postdoctorates on campus, a similar drop—from 69 to 53 percent—is observed for those in full-time faculty ranks. The increasing designation of research activities as primary work responsibility strongly suggests that the relative balance between teaching and research has shifted toward the latter, at least in the perception of these respondents. Those with other types of primary work responsibility—for administrative or managerial functions, service activities, and the like—constituted 13 to 19 percent of the total, and 11 to 17 percent among full-time faculty over the period, and thus have little influence on the apparent shift toward increased research emphasis. (See appendix table 6-30.)

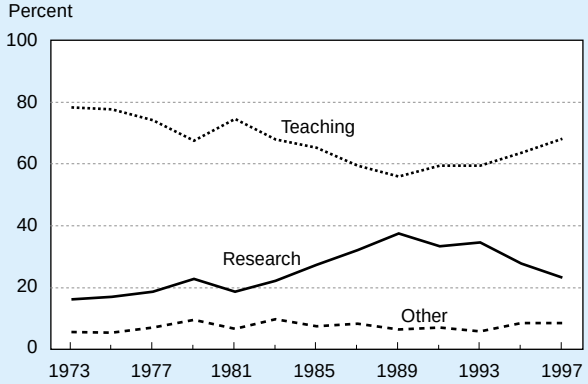
S&E doctorates in full-time faculty positions who earned their Ph.D. in the three years preceding the survey year show an interesting variation of this trend. From 1973 through the late 1980s, their percentage reporting teaching as primary responsibility declined from 78 to 56 percent, while that reporting research as primary rose from 16 to 38 percent. In the 1990s, these trends have reversed, with 68 percent choosing teaching and 23 percent designating research in 1997. (See figure 6-20 and appendix table 6-31.)

Federal Support of Academic Researchers

In 1997, 39 percent of the academic doctoral scientists and engineers reported receiving Federal funding for their research. (See appendix table 6-32.) This was in line with 1993 and 1995 findings, even as the number of academic researchers has expanded. These 1990s numbers reflect reports based on a question about the week of April 15 of the SDR survey year; those from earlier years (except 1985) were based on Federal support received over an entire year. If the volume of academic research activity is not uniform over the entire academic year, but varies to accommodate teaching and other activities, a one-week or one-month reference period will understate the number supported over an entire year.[48] Thus, the 1993–97 numbers (and 1985) cannot be compared directly to results for the earlier years. This earlier—1973–91—series indicates a decline in the proportion of federally supported researchers that coincided with stagnant real Federal R&D funds to academia during much of the 1970s (see chapter 2), followed by a rise in the proportion supported during the 1980s, especially during the latter half when Federal academic R&D funds again rose robustly.

Notable and persistent field differences exist in the proportion of researchers supported by Federal funds.[49] Above the overall S&E average are those with doctorates in the life, environmental, and physical sciences and engineering. Clearly below the mean are those in mathematics, psychology, and the social sciences. The relative position of these fields has not changed substantially over the past two decades. (See appendix table 6-32.)

Figure 6-20.
Distribution of primary work activity of recent S&E Ph.D.s in full-time academic faculty positions: 1973–97



NOTE: Recent Ph.D.s have earned their doctorate in the three years preceding the survey year.

See appendix table 6-31. *Science & Engineering Indicators – 2000*

Science and Public Policy (Steelman report)
Part One—Science for the Nation, I.
Science and the National Interest

Areas for United States Action

In light of the world situation and the position of science in this country, this report will urge:…

5. That a Federal program of assistance to undergraduate and graduate students in the sciences be developed as an integral part of an overall national scholarship and fellowship program. (Steelman 1947, 6.)

Financial Support for S&E Graduate Education

U.S. research universities have traditionally coupled advanced education with research—in the process providing scientific and engineering personnel as well as generating new knowledge. This integration of research and advanced training in S&E has served the country well as U.S. research universities attract graduate students from across the nation and the world. Upon receipt of their advanced degrees, these students set out to work in many sectors of the U.S. and other

[48]Indirect evidence that the extent of support is understated can be gleaned from the number of senior scientists and postdoctorates supported on NSF grants. This number is published annually as part of NSF's budget submission. It bears a relatively stable relationship to numbers derived from SDR in 1987, 1989, and 1991, but diverges sharply starting in 1993. (The figures from the two data sources are never identical, however, since NSF's numbers reflect those funded in a given fiscal year, while SDR numbers reflect those who have support from NSF regardless of when awarded.)

[49]The relative field shares of federally supported researchers appear to be stable across recent survey years, that is, they are relatively unaffected by changes in the survey reference period. The distribution (but not the estimated number) based on NSF estimates is quite similar.

economies, using the skills and knowledge they have acquired to meet a broad range of challenges.

This close coupling of education and research is reflected in the variety of forms in which financial support is provided to S&E graduate students, and particularly to those who are pursuing doctoral degrees. Support mechanisms include fellowships, traineeships, research assistantships (RAs), and teaching assistantships (TAs). Sources of support include Federal agency support, non-Federal support, and self-support. See "Definitions and Terminology" below for fuller descriptions of both mechanisms and sources of support. Most graduate students, especially those who go on to receive a Ph.D. degree, are supported by more than one source and one mechanism during their time in graduate school, and individual graduate students may even receive support from several different sources and mechanisms in any given academic year.

This section focuses on both sources and mechanisms of financial support, with special emphasis on the role of the research assistantship, since this form of support is so closely linked to the availability of academic R&D funds. Financial support is examined both for students who have just received their S&E doctorate degree and for all full-time S&E graduate students, since different types of information are available for these two distinct groups (see footnotes 51 and 52). Many of the discussions about U.S. graduate education focus on the appropriateness of the mechanisms currently used to support graduate students.[50] Documentation of the current structure and how it has evolved over time helps facilitate these discussions. For a more in-depth treatment of graduate education in general, see chapter 4, "Higher Education in Science and Engineering." For discussion of the relationships between financial support and graduate educational outcomes, see "Graduate Modes of Financial Support and Time to Degree" and "Relationship Between Support Modes and Early Employment of Recent S&E Ph.D.s." sidebars later in this chapter.

Definitions and Terminology

- **Fellowships** include any competitive award (often from a national competition) made to a student that requires no work of the recipient.
- **Traineeships** are educational awards given to students selected by the institution.
- **Research assistantships** are support given to students for which assigned duties are primarily devoted to research.
- **Teaching assistantships** are support given to students for which assigned duties are primarily devoted to teaching.
- **Other mechanisms of support** include work/study, business or employer support, and support from foreign governments that is not in the form of one of the earlier mechanisms.
- **Self-support** is support derived from any loans (including Federal loans) or from personal or family contributions.
- **Federal support** is support received from Federal agencies including through the GI bill and members of the Armed Forces whose tuition is paid by the Department of Defense.
- **Non-Federal support** is support received from the student's institution, from state and local government, from foreign sources, from nonprofit institutions, and from private industry.

Support of S&E Graduate Students[51] and S&E Doctorate Recipients[52]

Trends in Support

Full-time S&E graduate student enrollment registered a slight decline in 1997 for the third consecutive year, as did the number of such students whose primary source of support was the Federal Government.[53] The number of those whose primary source of support was from non-Federal sources rose slightly after declines in 1995 and 1996. (See appendix table 6-33.)

The proportion of graduate students with research assistantships (RAs) as their primary support mechanism increased from 22 to 28 percent between 1980 and 1989, a level about where it has since remained. This shift toward the use of RAs

[50]See COSEPUP (1995), NSB (1996), and NSF (1996a).

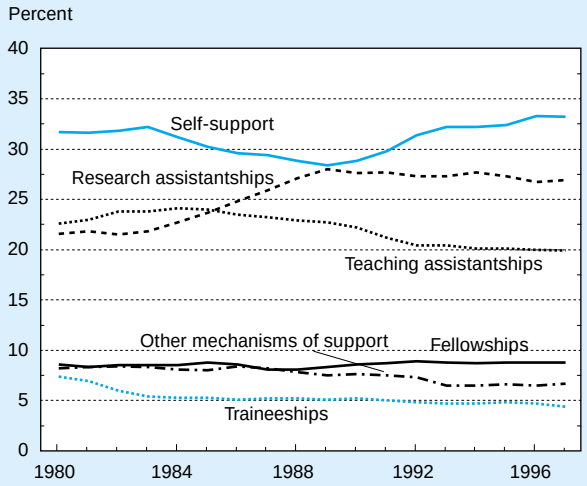
[51]The data presented on mechanisms and sources of support for S&E graduate students are from the NSF-NIH annual fall Survey of Graduate Students and Postdoctorates in Science and Engineering (NSF 1999f). In this survey, departments report the primary (largest) source and mechanism of support for each full-time degree-seeking S&E graduate student. No financial support data are collected for part-time students. Many of the full-time students may be seeking master's degrees rather than Ph.D. degrees, particularly in fields such as engineering and computer sciences. Since departments are aware of both primary sources and mechanisms of support for their students, both of these can be examined. Throughout this section, S&E includes the health fields (medical sciences and other life sciences).

[52]The data presented on mechanisms of support for S&E doctorate recipients are from the annual Survey of Earned Doctorates (NSF 1999i). Students who have just received their Ph.D.s are asked to respond to this survey. They are asked to identify their primary and secondary sources of support during graduate school as well as to check all other sources from which support was received. Validation studies on the quality of the data received from respondents to this survey indicate that the information on mechanisms of support is much better than that on sources. (See NRC 1994.) This is especially true for students whose primary support is a research assistantship, since they may not always know who is providing the funds that are supporting them. For this reason, the discussion of doctorate recipients is confined to mechanisms of support except for self-supported students. Twelve percent of the respondents in 1997 did not report a primary mechanism of support.

[53]Total Federal support of graduate students is underestimated since reporting on Federal sources includes only direct Federal support to a student and support to research assistants financed through the direct costs of Federal research grants. This omits students supported by departments through the indirect costs portion of research grants; such support would appear as institutional (non-Federal) support, since the university has discretion over how to use these funds.

was offset by a decline in the proportions supported by traineeships and self-support. During the 1990s, the proportion of students with traineeships as their primary support mechanism continued to decline, and the proportion of those with teaching assistantships (TAs) also began to decline. The relative decline in the use of these two mechanisms was balanced by an increase in the proportion reporting self-support. (See figure 6-21.)

Figure 6-21.
Primary support mechanisms for full-time S&E graduate students: 1980–97



NOTE: S&E also includes the health fields (medical sciences and other life sciences).

See appendix table 6-33. *Science & Engineering Indicators – 2000*

These overall shifts in the relative importance of primary RA support occurred for both students supported primarily by Federal sources and for those supported by non-Federal sources (this excludes students whose primary source of support is self-support). Among students whose primary source of support was the Federal Government, the rise in the proportion of those with an RA was offset by a fall in the proportion of those with a traineeship. Among students whose primary source was non-Federal, the shift toward RAs was balanced by a shift away from TAs.

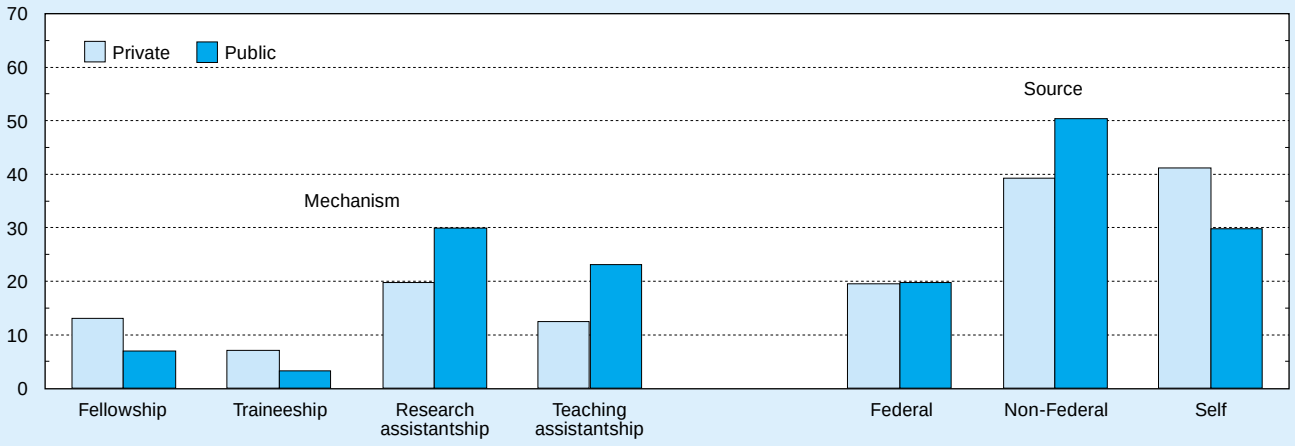
Patterns of Support by Institution Type

The proportion of full-time S&E graduate students with primary support from various sources and mechanisms differs for private and public universities. (See figure 6-22 and appendix table 6-34.) A larger proportion of full-time graduate students rely primarily on self-support in private academic institutions as opposed to those in public institutions—41 versus 30 percent in 1997.

Non-Federal sources are the primary source of support for a larger proportion of students in public institutions (50 percent) than in private ones (39 percent). About 20 percent of students in both private and public institutions receive their primary support from the Federal Government.

A larger proportion of students attending public academic institutions rely on research assistantships and teaching assistantships as their primary support mechanism (30 percent and 23 percent, respectively) than those attending private institutions (20 percent and 12 percent, respectively). This is balanced by greater reliance on fellowships and traineeships in private institutions (13 percent and 7 percent, respectively) than in public ones (7 percent and 3 percent, respectively).

Figure 6-22.
Primary support of full-time S&E graduate students, by mechanism and source for private and public universities: 1997



NOTES: Mechanism percentages do not total to 100 percent because other mechanisms are not included. S&E also includes the health fields (medical sciences and other life sciences).

See appendix table 6-34. *Science & Engineering Indicators – 2000*

Graduate Modes of Financial Support and Time to Degree

There is considerable interest in whether the amount and type of financial support given to graduate students has an effect on outcomes such as degree completion rates, time to degree, and productivity and success in the labor market. Unfortunately, it is extremely difficult to examine many of these impacts analytically either because of the absence of data, the subjective nature of the data that is available, or the inability to capture the outcomes quantitatively. In addition, most graduate students depend on multiple sources and mechanisms of support while in graduate school, and frequently on different sources and mechanisms in different phases of graduate work. This makes it quite difficult, if not impossible, to identify a one-to-one relationship between a student and a support source or mechanism.

Despite these difficulties, various studies have looked at some aspects of graduate support and student outcomes. A recent review of this literature summarized the results as follows (Bentley and Berger 1998a):

- The bulk of the evidence suggests that students receiving financial support enjoy higher completion rates and shorter time to degree than students without financial support.
- The evidence of the differential effects of alternative support mechanisms on completion rates is inconsistent. However, students holding fellowships appear to finish doctoral programs more quickly than teaching and research assistants.

A recent analysis prepared for NSF (Bentley and Berger 1998b) examined the effects of primary graduate support mechanisms reported by science and engineering research doctorate recipients on time to degree. Early on in this analysis it was found that the primary graduate support mechanisms identified by these doctorate recipients are not randomly distributed across factors that are likely to affect outcomes. Students majoring in some fields are more likely to receive one type of support than those majoring in others. Nonrandom assignment of primary support mechanisms across personal characteristics was also observed. For example, older students who are married and have dependents are more likely than other groups to report being self-supported. Men are more likely than women to report primary support from research assistantships. Students who do not switch fields between degrees are more likely to rely on research assistantships for primary support, while field switchers are more likely to be self-supporting. Because of this nonrandom assignment, it was necessary to use multivariate analyses to measure the impacts of support mechanisms on outcomes. Variables included in this analysis in addition to primary support mechanism include doctoral field, personal characteristics (for example, age, race/ethnicity, citizenship, marital status), parents' education, field and institution paths (that is, how often individuals switch academic fields and institutions), and cumulative debt.

The study found relatively large differences in the simple averages of time to degree* computed across alternative support mechanisms before the variables mentioned above were included in the analysis. For example, the mean total time to degree for students primarily supported by fellowships was 7.86 years, significantly less than the 10.33 years for self-supporting students. However, much of the differences in average time to degree across support mechanisms disappear when the effects of the additional variables are accounted for in the multivariate analysis. In the example above, after controlling for those other factors affecting time to degree, students primarily supported by fellowships complete their Ph.D. just 0.65 years faster than self-supporting students, rather than 2.47 years faster. The multivariate analysis also showed relatively small differences in time to degree across alternative types of support. For example, students supported by fellowships complete doctorates only about one-third of a year faster than students supported by teaching assistantships, and the latter complete degree requirements nearly as fast as research assistants.

Even after controlling for a number of variables, the study had several limitations that need to be considered in interpreting the findings. One of the main difficulties is a selection problem that is not easily overcome. Fellowships and assistantships are probably awarded on the basis of ability and achievement. Some of the measured effects of these types of support may be due to student characteristics, rather than to the receipt of the award. For example, if students awarded fellowships have better academic credentials than others do, one might expect them to finish their doctorates more quickly. To the extent that graduate support allocation decisions are successful in sorting students by merit and aptitude, it becomes more difficult to statistically isolate the effect of receiving graduate support from the effects of other student differences.

*The discussion below refers to total time to degree, which is defined as years elapsed between the date of the bachelor's degree and the date of the doctorate. There are alternative measures of time to degree that can be analyzed including graduate time to degree (years elapsed between the date of entry into the first graduate program and the date of the doctorate) and registered time to degree (number of years registered in the graduate program before receiving the doctorate).

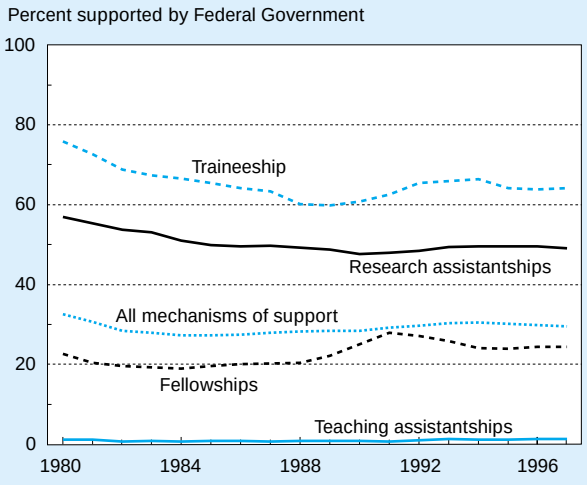
The Federal Government plays a larger role as the primary source of support for some mechanisms than for others. (See figure 6-23.) A majority of traineeships in both private and public institutions (54 percent and 73 percent, respectively) are financed primarily by the Federal Government, as are 60 percent of the research assistantships in private institutions and 46 percent in public institutions. The Federal Government provides the primary support for less than 30 percent of fellowships and less than 2 percent of teaching assistantships in both public and private institutions.

Support Patterns for All S&E Graduate Students Versus Doctorate Recipients

Most full-time S&E graduate students do not go on to receive a Ph.D., and many never intend to do so. Consequently, it is likely that the financial support patterns of full-time S&E graduate students will differ from those of S&E Ph.D. recipients. While the data from the two surveys are not strictly comparable, it is useful to compare the primary support patterns of those students who do earn a Ph.D. with the patterns for all full-time S&E graduate students to see if they provide a rough indicator of differences among these two groups.[54] Thirty-four percent of the students receiving their science and engineering Ph.D.s in 1997 reported that their primary mechanism of support during their time in graduate school was a research assistantship. This is somewhat higher than the percentage (27 percent) of full-time science and engineering students for whom a research assistantship was reported as the primary mechanism of support. Fellowships and teaching assistantships were reported less frequently as a primary mechanism of support by those students who earned an S&E Ph.D. (2 percent and 15 percent, respectively) than for all full-time S&E graduate students (9 percent and 20 percent, respectively). Traineeships, however, were reported more frequently by those receiving an S&E Ph.D. (7 percent) than for graduate students in general (4 percent). A considerably smaller percentage of students receiving an S&E Ph.D. reported self-support as their primary means of support (20 percent) than did graduate students in general (33 percent). (See appendix tables 6-35 and 6-36.) For a brief discussion of overall rather than primary support for S&E Ph.D.s see sidebar, "Multiple Modes of Financial Support for S&E Ph.D.s."

[54]As noted earlier, the data for these two groups are derived from two distinct surveys with different reporting entities and different time frames.

Figure 6-23.
Percentage of full-time S&E graduate students with the Federal Government as primary source of support, by primary mechanism of support: 1980–97



NOTES: Data shown here do not include students for whom self-support is their primary source of support. S&E also includes the health fields (medical sciences and other life sciences).

See appendix table 6-33. *Science & Engineering Indicators – 2000*

Support Patterns for S&E Doctorate Recipients by Citizenship, Sex, and Race/Ethnicity

The data on financial support for S&E Ph.D.s also permit one to look at differences in support patterns by citizenship status, sex, and race/ethnicity;[55] this is not possible with the graduate student data.[56] (See appendix table 6-37.) Foreign S&E Ph.D. recipients—whether on temporary or permanent visas—were more likely than U.S. citizens to report a research assistantship (44 and 45 percent versus 32 percent) or a teaching assistantship (20 and 19 percent versus 14 percent) as their primary support mechanism and less likely than U.S. citizens to report a fellowship (1 percent versus 3 percent), traineeship (5 and 8 percent versus 9 percent), or self-support (11 and 15 percent versus 27 percent).[57]

Among U.S.-citizen doctorate recipients, men were much more likely than women to report a research assistantship (35 versus 27 percent) and much less likely to report self-support (22 versus 33 percent) as their primary support modes. Although sex differences also existed in the use of fellowships, traineeships, and teaching assistantships, these were much smaller than the above-mentioned differences.

Also, among U.S.-citizen S&E Ph.D.s, underrepresented minorities (American Indians, Alaskan Natives, blacks, and Hispanics) were less likely than either Asians and Pacific Islanders or whites to report research assistantships (21 percent versus 41 and 32 percent) and teaching assistantships (8 percent versus 10 and 15 percent) as their primary support mechanism and more likely to report fellowships (6 percent versus 4 and 3 percent) and traineeships (16 percent versus 9 and 8 percent). They were also more likely to report self-support (26 percent) than Asians and Pacific Islanders (17 percent), but less likely than whites (28 percent). (See figure 6-24.) See "The Debt Burden of New Science and Engineer-

[55]Since the Survey of Earned Doctorates obtains data from individual respondents, information is available about demographic characteristics such as citizenship, race/ethnicity, and sex.

[56]For information on the distribution of and trends in S&E Ph.D.s by sex, race/ethnicity, and citizenship status, see chapter 4, "Higher Education in Science and Engineering."

[57]Foreign S&E Ph.D. recipients, especially those on temporary visas, are often not eligible for either Federal loan programs (included in self-support) or Federal fellowships.

Multiple Modes of Financial Support for S&E Ph.D.s

A recent NSF study (NSF 2000a) examined the entire matrix of support patterns of science and engineering (S&E) research doctorates in 1995 (not only their primary forms of support), showing the distribution of various modes of support to individuals. The Survey of Earned Doctorates, which served as the main source of data for this study, allowed new Ph.D.s to select from 32 separate support options all the forms of support that they may have used during graduate school. In the study, these 32 support options were combined into 7 modes of support:

- ♦ fellowship,
- ♦ traineeship,
- ♦ research assistantship (RA),
- ♦ teaching assistantship (TA),
- ♦ own funds,
- ♦ loans, and
- ♦ other.

The study found that 1995 S&E Ph.D.s commonly relied on more than one mode of support. The average number of modes of support was 2.5 and varied by field, sex, race/ethnicity, and citizenship. Women tended to rely on more support modes than men in S&E as a whole and in most fields. Asians and Pacific Islanders and noncitizens reported fewer modes of support on average than did other groups.

Among S&E Ph.D.s as a whole (looking at all forms of support reported rather than only the primary mode of support), women were more likely to report having used traineeships, their own funds, or loans than were men. Men were more likely than women to receive support in the form of RAs. For the most part, differences between women's and men's reliance on own funds and RAs are related to differences in field of doctorate. Women are more likely than men to be in psychology and in health sciences—fields in which reliance on one's own funds is common—and men are more likely than women to be in engineering and physical sciences—fields in which reliance on RAs is common.

Among both Asian and Pacific Islander and noncitizen S&E Ph.D. recipients, RAs were the most frequently reported modes. In contrast, the support mode identified by the largest percentage of both underrepresented minorities (American Indians, Alaskan Natives, blacks, and Hispanics) and whites was their own funds. Whites and underrepresented minorities were also more likely to report the use of loans than were Asians and Pacific Islanders or noncitizens, and underrepresented minorities were more likely to report the use of both fellowships and traineeships than other groups. Although some of these variations in modes of support were found to be due to field differences, field differences did not explain all of the racial/ethnic variations. For instance, Asians and Pacific Islanders reported the largest use of RAs in every field except the computer sciences and psychology. Also, in every field, a larger percentage of both underrepresented minorities and whites reported using their own funds and loans than did Asians and Pacific Islanders or noncitizens. Further, in almost every field, higher percentages of underrepresented minorities than other groups reported using fellowships and traineeships.

Five combinations of support modes out of a possible 127 were reported by slightly less than half of all 1995 S&E Ph.D. recipients. Two combinations—RA+TA and RA+own funds—accounted for about 20 percent of all combinations of modes. RA+TA+own funds and RA alone were the third and fourth most frequent combinations. TA+own funds was the fifth most frequently used combination. Combinations of support modes differ by sex within some fields. For example, in the health sciences, 12 percent of women and 6 percent of men reported using their own funds as their only mode of support. In mathematics, women and men have the same top four combinations of support but the predominant combination for men was RA+TA and for women TA+own funds.

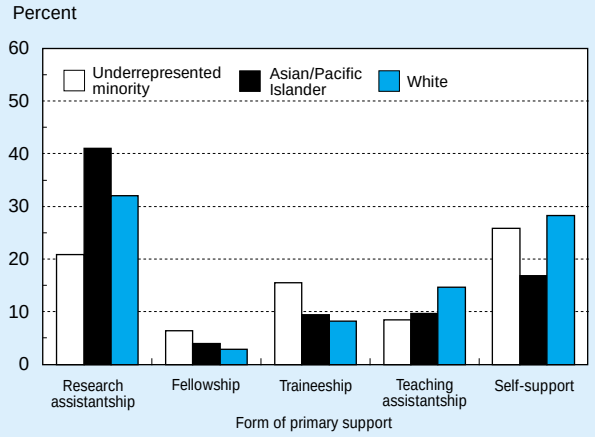
Underrepresented minorities were found to use a wider range of funding combinations and relied more on loans and own funds than did Asians and Pacific Islanders and noncitizens. Each of the five top combinations of modes of support of underrepresented minorities involved use of their own funds and accounted for only 22 percent of minority Ph.D. recipients. In contrast, just under 40 percent of those of Asian or Pacific Islander background received their support from the RA+TA combination or RA alone, and the top five combinations accounted for the support of about 60 percent of those Ph.D.s.

ing Ph.D.s" later in this chapter for differences in the debt situation of U.S. citizen and foreign Ph.D. recipients, among racial/ethnic groups, and between men and women.

Since the field distribution of S&E Ph.D. degrees varies across demographic groups, and the patterns of support differ by S&E field, some of the differences reported above could be mainly the result of degree field distribution differences. However, the data indicate that although degree field distribution does explain a great deal of the difference in relative importance of primary support mechanisms between men and women, it does not account for the differences across either citizenship status or race/ethnicity. (See appendix tables 6-38, 6-39, and 6-40.)

In the case of foreign S&E Ph.D. recipients, the relative importance of RAs and TAs as primary support mechanisms

Figure 6-24.
Primary forms of support for 1997 U.S. citizen S&E Ph.D. recipients, by race/ethnicity



NOTES: Percentages do not total to 100 due to omission of other nonspecified forms of support, nonrespondents, and rounding. Underrepresented minorities include American Indians, Alaskan Natives, blacks, and Hispanics. S&E also includes the health fields (medical and other life sciences).

See appendix table 6-37. *Science & Engineering Indicators – 2000*

found in the aggregate compared to U.S. citizens also holds for most S&E fields, and is particularly strong in both engineering and the computer sciences. Similarly, the lesser relative reliance on self-support holds in all the broad disciplinary areas, while the comparatively minor roles of fellowships and traineeships for foreign doctorate recipients holds in about half of these fields. (See appendix table 6-38.)

Although among U.S. citizens female S&E doctorate recipients were less likely than males to report an RA as their primary support mechanism at the aggregate level, this was not the case in many S&E fields. In five broad fields—mathematics, environmental sciences, biological sciences, psychology, and social sciences—women were either more or equally likely as men to report an RA as their primary support mechanism. (See appendix table 6-39.) In addition, in many fields, differences between men and women in the percentage reporting an RA as their primary support mechanism were in the 1 to 3 percentage point range rather than the 8 percentage point aggregate differential. Only in the computer sciences was this differential large—20 percent of the women reported an RA, compared to 34 percent of the men.

The level of the aggregate difference in reliance on RAs between men and women can be explained by the fact that a much larger percentage of women (29 percent) received their Ph.D. degrees in psychology—a field where RAs are not a very important primary means of financial support—than did men (9 percent). The level of the aggregate difference between sexes in the reliance on self-support as a primary mode of support can be similarly explained. Once again, in this case, individual fields do not follow the aggregate pattern. In the environmental sciences, agricultural sciences, biological sciences, and engineering, women were less likely than men to identify self-support as their primary means of support. And in the fields where women were more likely to rely on self-support than men, only in the health sciences was the difference between them (52 percent versus 39 percent) as large as the aggregate difference reported. In the other fields, differences ranged between 1 and 5 percentage points.

In the case of U.S.-citizen underrepresented minority S&E Ph.D. recipients, the aggregate findings also hold for most broad disciplinary areas. (See appendix table 6-40.) For example, only in the health sciences is the percentage of underrepresented minorities higher than the percentage of white Ph.D. recipients reporting RAs as their primary mechanism of support. And only in the social sciences is the percentage of underrepresented minorities higher than the percentage of Asian and Pacific Islander Ph.D. recipients reporting RAs as their primary mechanism of support.

Science and Public Policy (Steelman report)
Part One—Science for the Nation, IV.
A National Science Program

Scientists for the Future

Our scientific strength depends neither solely upon our present supply of scientists, nor upon those students now being trained. It depends ultimately upon a steady flow of able students into our colleges and universities. What we require as a Nation is to extend educational opportunities to all able young people, leaving it to them to determine the field of study they desire to pursue. In normal times, freedom of choice must be allowed to operate in education, as well as elsewhere, if we are to preserve our free institutions. No agency of the Government is sufficiently far-seeing—nor ever likely to be—to foretell 15 or 20 years in advance the fields in which we shall need most trained people. In free competition, the physical and biological sciences will get their share.

The expanding grants in support of basic research will provide an opportunity for the employment of more graduate students in such research programs. This will enable the universities themselves to choose the best of their present students as research assistants and will in turn result in better scientific training. (Steelman 1947, 35-6.)

Research Assistantships as a Primary Mechanism of Support

Graduate Research Assistantships by S&E Field

Research assistantships accounted for 27 percent of all support mechanisms for full-time S&E graduate students in 1997. However, the mix of support mechanisms, and thus the

Relationship Between Support Modes and Early Employment of Recent S&E Ph.D.s

A recent NSF Issue Brief (NSF 1998a) examined the relationships between the primary mechanism of financial support reported by recent science and engineering (S&E) Ph.D.s* and the sector in which they were employed and their primary work activity within one to two years after conferral of their doctorate.

Since 1979, in every year of the biennial Survey of Doctorate Recipients (odd years), about half of recent S&E Ph.D.s with primary research assistantship, fellowship, traineeship, or teaching assistantship support were working in academic institutions. However, with a few minor exceptions, since 1979 those with primary RA support had a relatively greater propensity for industry employment—and a lower propensity for academic jobs—than those with primary fellowships, traineeships, and teaching assistantships. (See text table 6-5.) For example, in 1995 industry employed a third of those with RA support, but only 21 percent of those with TA support, 19 percent of those with fellowships, and 15 percent of those with traineeships. Academic institutions employed 51 percent of those with RA support, but 61 percent of those with fellowship, 65 percent of those with traineeship, and 66 percent of those with TA support.

A small number of universities—about 125**—dominate the conduct of academic research, while a much larger number—about 1,600—award four-year and advanced degrees in science and engineering. The study found that RA- and fellowship-supported S&E Ph.D.s who did enter academic employment disproportionately ended up working at these research universities. From 1979 to 1995, these institutions employed from 59 to 68 percent of all the recent S&E Ph.D.s who were working in colleges and universities, but 71 to 84 percent of those in academic employment who had primary RA support, and 72 to 90 percent of those with primary fellowship support.

The study also found that although recent S&E Ph.D.s tended to designate research as their primary activity more frequently than teaching, their responses differed with primary support mode. (See text table 6-5.) In 1995, 73 to 75 percent of recent S&E Ph.D.s with research assistantships and fellowships identified research as their primary job activity, compared to 56 percent overall, 54 percent of those with traineeships, and 40 percent of those with a teaching assistantship. This pattern also has been quite consistent since 1979, although 1995 is anomalous for the relationship between traineeships and work activity that appeared to hold during 1979–93.

A significantly greater percentage of those with teaching assistantships as primary support and a significantly smaller percentage of those with a research assistantship were likely to report teaching as their primary work activity than the overall population of recent S&E Ph.D.s. This was true throughout the 1979–95 period. For S&E Ph.D.s with fellowships or traineeships, the propensity to report teaching as their primary work activity varied over these years.

The available data do not provide any information about the causes of these patterns. Therefore it is not clear whether students who desire careers as researchers or in industry seek out RA support or whether the experiences associated with RA support influence the choice of employment sector and type of work sought by recent S&E Ph.D.s. In addition, the relationships between primary support mechanism, employment sector, and primary work activity may in part reflect factors not examined here, particularly distribution of support mechanisms across specific fields and sectoral employment differences across these fields.

*Data for this analysis were from NSF's annual Survey of Earned Doctorates (primary support mode) and its biennial Survey of Doctorate Recipients (sector of employment and primary work activity). For this analysis, recent S&E Ph.D.s are defined as those receiving their doctorate degree in the two years preceding the biennial Survey of Doctorate Recipients.

**The Carnegie Commission calls them the Research Universities.

role of research assistantships as the primary support mechanism, differs by S&E field. (See appendix table 6-36.) RAs comprise more than 50 percent of the primary support mechanisms for graduate students in atmospheric sciences, oceanography, agricultural sciences, chemical engineering, and materials engineering. They account for less than 20 percent in all the social sciences, mathematics, and psychology.

The number of graduate students with a research assistantship as their primary mechanism of support increased from just over 50,000 in 1980 to a peak of 92,000 in 1994, and by 1997 fell to 88,000. (See appendix table 6-41.) In just about every S&E field, the percentage of graduate students with a research assistantship as their primary means of support was higher in 1997 than in 1980. The largest increases were in the biological sciences (14 percentage points), in both the agricultural and the medical sciences (10 percentage points each), and in a number of engineering fields—electrical/electronic engineering (11 percentage points), chemical engineering (10 percentage points), and civil and industrial engineering (9 percentage points each). (See figure 6-25.)

All S&E Graduate Students Versus Doctorate Recipients

Although not strictly comparable, data from the Ph.D. and graduate student surveys suggest that the relative utilization of a research assistantship as a primary mechanism of sup-

Text table 6-5.
Percent of recent S&E Ph.D.s working in academe or industry, or with research or teaching as primary work activity, by selected primary mechanism of support: 1979–1995

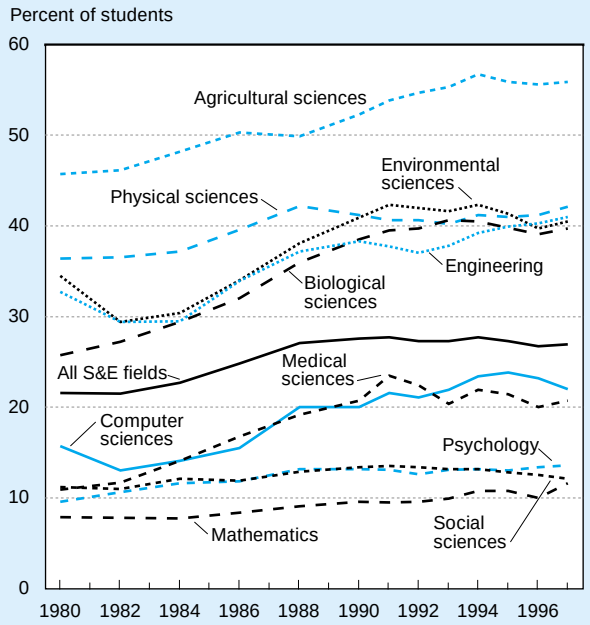
	All	Research assistantship	Teaching assistantship	Traineeship	Fellowship
			Work sector		
Academe					
1979	52	49	60	68	56
1981	50	44	61	62	55
1983	49	48	58	60	59
1985	50	49	59	55	65
1987	47	45	60	55	43
1989	49	45	57	68	75
1991	49	46	58	62	63
1993	51	49	71	58	62
1995	54	51	66	65	61
Industry					
1979	21	30	24	14	20
1981	27	39	23	13	27
1983	26	35	26	16	17
1985	25	32	22	17	23
1987	24	31	18	19	26
1989	25	30	23	13	17
1991	26	32	23	20	19
1993	28	34	16	21	28
1995	27	33	21	15	19
			Primary work activity		
Research					
1979	47	60	47	52	56
1981	51	76	44	54	73
1983	53	70	50	63	73
1985	53	73	50	71	60
1987	56	76	55	74	66
1989	59	78	59	73	79
1991	56	75	46	64	75
1993	58	75	47	69	80
1995	56	75	40	54	73
Teaching					
1979	24	15	34	24	24
1981	22	11	35	21	17
1983	21	15	28	17	9
1985	20	15	31	12	26
1987	19	12	30	7	21
1989	18	8	31	11	17
1991	19	11	34	17	13
1993	17	8	38	14	11
1995	18	9	35	20	15
Average N	28,487	7,958	4,290	2,833	746

NOTES: Recent S&E Ph.D.s are those receiving their degrees in the two years preceding the survey year of the biennial Survey of Doctorate Recipients. Percentages represent the percent of recent S&E Ph.D.s in each year that work in academe and industry or that report research and teaching as primary work activity, but do not sum to 100 percent since employment sectors other than academe and industry and work activities other than research and teaching are not shown. Industry includes self employment. “Average N” is average number of recent S&E Ph.D.s across the nine survey years for each primary support mechanism and for the “All” category includes all recent S&E Ph.D.s including those with mechanisms not shown (own/family resources, loans, other nonspecified, and missing).

SOURCES: National Science Foundation, Division of Science Resources Studies (NSF/SRS), Survey of Earned Doctorates and Survey of Doctorate Recipients, various years, special tabulations.

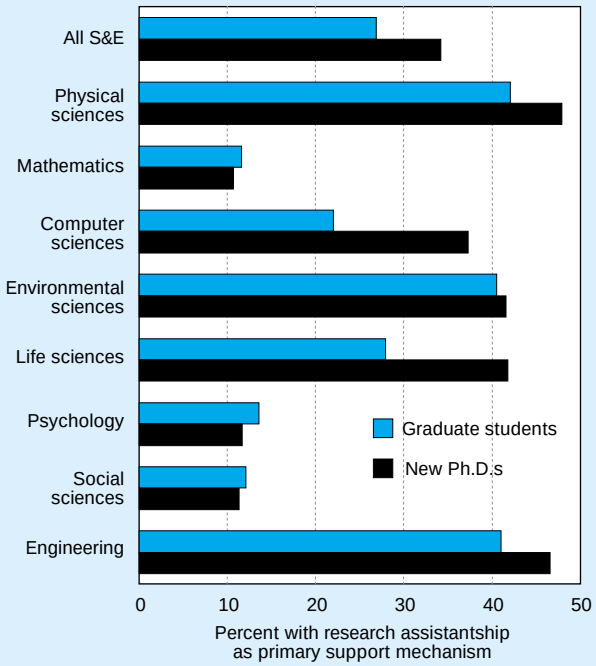
Science & Engineering Indicators – 2000

Figure 6-25.
Percentage of full-time S&E graduate students with a research assistantship as primary mechanism of support, by field: 1980–97



See appendix table 6-41. *Science & Engineering Indicators – 2000*

Figure 6-26.
Indicator of relative importance of research assistantships as primary mechanism of support for full-time S&E graduate students and S&E Ph.D. recipients, by field: 1997



NOTES: Since the data for graduate students and Ph.D.s are derived from two distinct surveys with different reporting entities and different time frames, these percentages are not strictly comparable. They are only intended to serve as a rough indicator of the similarities and differences between relative use of RAs as a primary support mechanism by the two groups. Life sciences also includes the health fields (medical sciences and other life sciences).

See appendix tables 6-35 and 6-36.

Science & Engineering Indicators – 2000

port was rather similar at a broad disciplinary level between full-time S&E graduate students and S&E Ph.D. recipients. (See figure 6-26.) Research assistantships were once again quite prominent in the physical sciences, environmental sciences, and engineering and much less prominent in mathematics, social sciences, and psychology. However, in both the life sciences and the computer sciences, research assistantships played a much larger role as a primary support mechanism for those receiving their doctorate than for the average full-time S&E graduate student.

Sources of Support

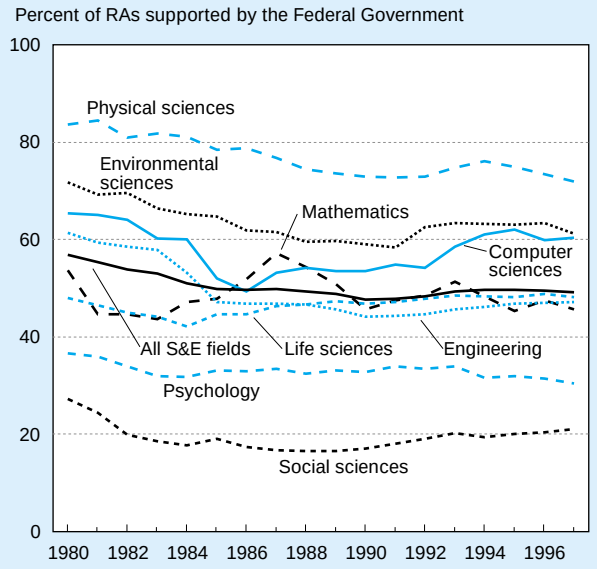
In 1997, about one-third of graduate research assistants were in the life sciences, with an additional 30 percent in engineering and 13 percent in the physical sciences. The Federal Government was the primary source of support for about half of all graduate students with a research assistantship as their primary mechanism of support. (See appendix table 6-42.) This proportion declined from 57 percent in 1980 to about 50 percent in 1985, where it has since remained. (See figure 6-27 and appendix table 6-43.) The Federal role, however, differs by S&E field. The Federal Government was the primary source of support for considerably more than half of the research assistants in the physical sciences (72 percent), the environmental sciences (61 percent), and the computer sciences (60 percent), and for considerably less than half in the social sciences (21 percent) and psychology (31 percent).

Federal Agency Support[58]

During most of the 1980s NSF was the Federal agency that was the primary source for the largest number of graduate research assistantships. It was surpassed by the entire HHS in 1989 and by NIH in 1993. (See appendix table 6-44.) Between 1980 and 1997, the percentage of Federal graduate research assistantships financed primarily by NIH increased from about 19 percent to 26 percent, while the percentage financed primarily by NSF increased from 26 percent to a peak of 28 percent in 1984, then fell to 24 percent. The DOD share has fluctuated between 10 and 16 percent over the same period and the USDA share between 6 and 7 percent (since it was first reported in 1985). NASA's share in 1997 (only the second year it was reported) was just under 5 percent.

[58]Only five Federal agencies are reported on individually as primary sources of support to S&E graduate students in the Survey of Graduate Students and Postdoctorates in Science and Engineering: DOD, NSF, USDA, NASA, and HHS, with the latter being reported as two distinct units—NIH and other HHS. DOE has been added to the 1999 survey.

Figure 6-27.
Percentage of full-time S&E graduate students with a research assistantship as primary support mechanism whose primary source of support is the Federal Government, by field: 1980–97



NOTE: Research assistants (RAs) are students for whom a research assistantship is reported as their primary mechanism of support. Life sciences also includes the health fields (medical sciences and other life sciences).

See appendix table 6-43. *Science & Engineering Indicators – 2000*

Just as Federal agencies emphasize different S&E fields in their funding of academic research, it is not surprising to find that they also emphasize different fields in their support of graduate research assistants. HHS and especially NIH concentrate their support in the life sciences (70 percent and 73 percent, respectively), as does USDA (74 percent). DOD concentrates its support in engineering (58 percent). NSF, on the other hand, has a more diversified support pattern, with just over one-third in engineering, 29 percent in the physical sciences, and 10 percent each in the environmental and the life sciences. (See figure 6-28 and appendix table 6-45.) Although an agency may place a large share of its support for research assistants in one field, it may not necessarily be a leading contributor to that field. (See figure 6-29 and appendix table 6-46.) NSF is the lead supporting agency in mathematics (41 percent of federally supported RAs), the environmental sciences (41 percent), the physical sciences (37 percent), and in engineering (29 percent). NIH is the lead support agency in the life sciences (60 percent), psychology (56 percent), and sociology (36 percent). DOD is the lead support agency in the computer sciences (43 percent) and in electrical engineering (45 percent), and also provides an almost identical level of support as NSF for total engineering. USDA is the lead support agency in the agricultural sciences (56 percent) and economics (52 percent). NASA is the lead support agency in astronomy (45 percent) and aeronautical/astronautical engineering (36 percent).

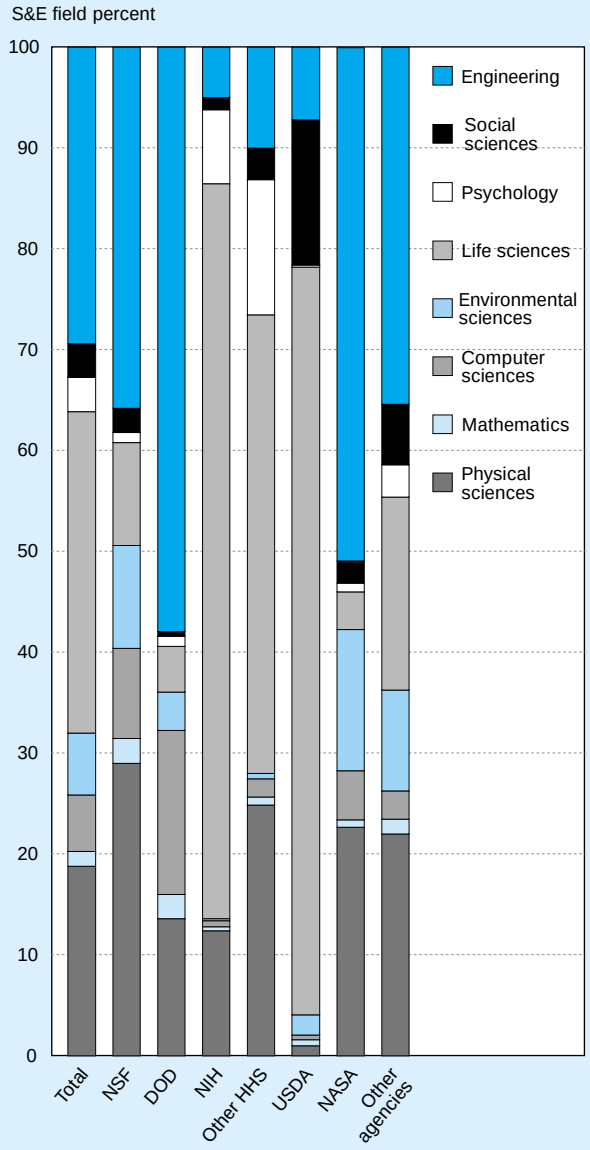
The Spreading Institutional Base

During the 1980–97 period, the number of universities and colleges reporting at least one full-time S&E graduate student with a research assistantship as his or her primary mechanism of support has fluctuated between 400 and 435, with a slight upward trend, reaching its highest level in 1993. Not surprisingly, however, there was basically no change in the number of currently designated Carnegie research or doctorate-granting institutions reporting at least one graduate student with primary research assistantship support during this period; this number fluctuated between 219 and 224. Since these institutions had probably been receiving research funds over the entire period, it is likely that they were supporting graduate students with research assistantships as their primary support mechanism. Thus, most of the fluctuation and the entire increase in the number of institutions reporting at least one graduate student receiving a research assistantship as their primary support mechanism occurred among comprehensive; liberal arts; two-year community, junior, and technical; and professional and other specialized schools. (See appendix table 6-47.) Only 46 percent of this group of schools reported at least one graduate student with an RA as primary support mechanism in 1980, compared to 57 percent in 1997.[59]

Throughout this period, considerably fewer institutions reported students with primary RA support financed primarily by the Federal Government than reported students with such support financed primarily from non-Federal sources. This difference is particularly pronounced among the "other" Carnegie institutions, 114 (32 percent) of which report RAs supported by the Federal Government in 1997 compared to 185 (51 percent) that report RAs financed by non-Federal sources. Why so many fewer other institutions report the Federal Government as a primary source of funds for research assistantships than receive R&D funds from the Federal Government is unclear.

[59]Percentages are calculated by dividing the number of schools reporting at least one RA into the number of schools responding to the survey. If an institution does not report any full-time graduate students with an RA as their primary support mechanism, it does not necessarily mean that the institution does not have any graduate students being supported by research assistantships. It simply indicates that the research assistantship is not the primary mechanism of support for any of the students attending that institution.

Figure 6-28.
Field distribution of full-time S&E graduate students with a research assistantship as primary support mechanism, by federal agency of primary support: 1997

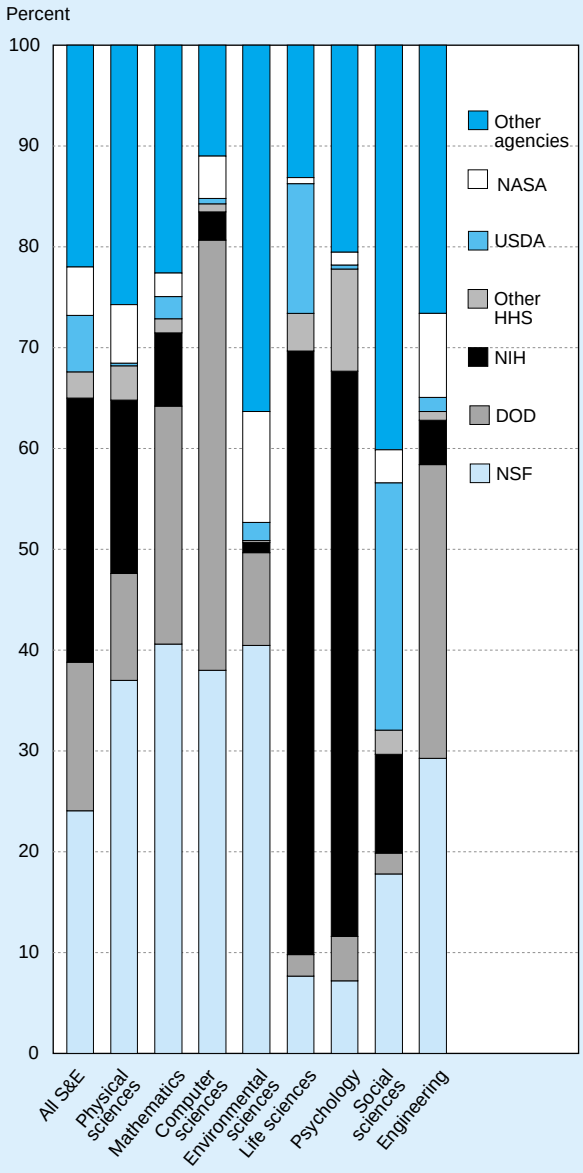


NSF = National Science Foundation; DOD = Department of Defense; NIH = National Institutes of Health: HHS = Department of Health and Human Services; USDA = Department of Agriculture; NASA = National Aeronautics and Space Administration

NOTE: The agencies cited here are the only ones for which graduate support data are reported in 1997. Life sciences also includes the health fields (medical sciences and other life sciences).

See appendix table 6-45. *Science & Engineering Indicators – 2000*

Figure 6-29.
Federal agency distribution of full-time S&E graduate students with a research assistantship as primary support mechanism, by field: 1997



NSF = National Science Foundation; DOD = Department of Defense; NIH = National Institutes of Health: HHS = Department of Health and Human Services; USDA = Department of Agriculture; NASA = National Aeronautics and Space Administration

NOTE: The agencies cited here are the only ones for which graduate support data are reported in 1997. Life sciences also includes the health fields (medical sciences and other life sciences).

See appendix table 6-46. *Science & Engineering Indicators – 2000*

The Debt Burden of New Science and Engineering Ph.D.s

Two NSF Issue Briefs (NSF 1998b and 1999c) examined the debt owed by 1993–96 science and engineering (S&E) doctorate recipients at the time of Ph.D. conferral for undergraduate and/or graduate education expenses (data do not allow them to be separated) for tuition and fees, living expenses and supplies, and transportation to and from school. Differences were highlighted in the debt situation of U.S. citizen and foreign Ph.D. recipients, among racial/ethnic groups, and between men and women.

The main findings of these studies were:

- U.S. citizens were more likely to report at least some debt, and to owe larger amounts, than were foreign students.
- Among U.S. citizens, a smaller percentage of underrepresented minority (American Indian, Alaskan Native, black, and Hispanic) S&E Ph.D. recipients were debt free compared to whites or Asians and Pacific Islanders. Among those with debt, underrepresented minorities reported higher levels of debt than their white or Asian and Pacific Islander counterparts.
- Among U.S. citizens there was little difference between the debt situation of men and women at the aggregate S&E level, but these aggregate findings actually masked some field differences in the debt situation between male and female S&E Ph.D. recipients.*

Data for 1997 S&E doctorate recipients show similar results to the earlier studies. (See text table 6-6.) Overall, just under half of those who received their S&E Ph.D.s in 1997 reported having no debt at the time of Ph.D. conferral. An additional 29 percent reported total debt burdens of $20,000 or less and another 14 percent reported debt levels exceeding $20,000.** Only 40 percent of U.S. citizen Ph.D.s reported being free of debt compared to two-thirds of those without U.S. citizenship. Nineteen percent of U.S. citizens reported debt burdens exceeding $20,000, and 37 percent reported debt of less than $20,000; for foreign Ph.D. recipients, comparable percentages were 9 and 21 percent, respectively.

Among U.S. citizens, only 28 percent of underrepresented minority S&E Ph.D. recipients reported not having any debt, compared to 41 percent for whites and 44 percent for Asians and Pacific Islanders. They also reported higher levels of debt than their white or Asian and Pacific Islander counterparts. Even though underrepresented minorities are more likely to receive their Ph.D.s in fields subject to greater likelihood and higher levels of debt (psychology and the social sciences), the aggregate differences are not primarily the result of field distribution differences. In each of the fields presented in text table 6-6, except for the environmental sciences, a smaller percentage of underrepresented minorities reported not having any debt than either whites or Asians and Pacific Islanders. In addition, in each field the percentage of underrepresented minorities reporting debt greater than $20,000 is always greater than the percentage of Asian and Pacific Islanders or whites reporting such debt.

Once again, in 1997, there was little difference at the aggregate level between the debt situation of men and women. Forty percent of each group reported having no debt. Thirty-six percent of the women reported debt less than $20,000 compared to 37 percent of the men; 20 percent reported debt exceeding $20,000 compared to 18 percent of men. However, in all but two of the fields presented in the text table—the computer sciences and the environmental sciences—a larger proportion of women reported not having any debt than did men. Some of the differences reported are substantial. Also, in most fields a smaller percentage of women than men reported debt exceeding $20,000.

*A major reason that aggregate data show similarities in the debt situation of men and women is that psychology, the field with the highest percentages and levels for educational debt, accounts for about 30 percent of women's S&E Ph.D.s compared to 10 percent of men's.

**Some respondents failed to furnish this information.

Text table 6-6.
Cumulative debt related to the education of S&E doctorate recipients, by citizenship status, sex, race/ethnicity, and field: 1997

Ph.D. field	Status	Number of Ph.D.s	Percent with		
			No debt	< or = $20K	>$20K
All S&E fields	All	28,241	47	29	14
	U.S. citizen	16,686	40	37	19
	Foreign	9,530	67	21	9
	Male (U.S. citizen)	9,948	40	37	18
	Female (U.S. citizen)	6,738	40	36	20
	Asian/Pacific Islander (U.S. citizen)	1,043	44	32	14
	White (U.S. citizen)	13,902	41	37	19
	Underrepresented minority (U.S. citizen)	1,238	28	40	27
Physical sciences	All	3,711	51	32	9
	U.S. citizen	2,112	40	43	12
	Foreign	1,376	73	19	6
	Male (U.S. citizen)	1,644	40	43	12

Text table 6-6.
Cumulative debt related to the education of S&E doctorate recipients, by citizenship status, sex, race/ethnicity, and field: 1997

Ph.D. field	Status	Number of Ph.D.s	Percent with		
			No debt	< or = $20K	>$20K
Physical sciences	Female (U.S. citizen)	468	41	44	11
	Asian/Pacific Islander (U.S. citizen)	155	45	38	8
	White (U.S. citizen)	1,779	41	44	12
	Underrepresented minority (U.S. citizen)	106	29	43	18
Mathematics	All	1,112	58	26	7
	U.S. citizen	516	50	36	9
	Foreign	516	73	18	5
	Male (U.S. citizen)	378	48	36	11
	Female (U.S. citizen)	138	55	37	4
	Asian/Pacific Islander (U.S. citizen)	34	44	26	9
	White (U.S. citizen)	440	52	37	9
	Underrepresented minority (U.S. citizen)	22	32	32	23
Computer sciences	All	889	59	22	9
	U.S. citizen	417	58	28	10
	Foreign	403	69	18	9
	Male (U.S. citizen)	336	58	29	10
	Female (U.S. citizen)	81	58	26	10
	Asian/Pacific Islander (U.S. citizen)	42	57	29	2
	White (U.S. citizen)	337	60	28	10
	Underrepresented minority (U.S. citizen)	20	40	40	20
Environmental sciences	All	862	51	30	9
	U.S. citizen	518	46	40	11
	Foreign	281	70	16	7
	Male (U.S. citizen)	380	47	39	11
	Female (U.S. citizen)	138	42	41	12
	Asian/Pacific Islander (U.S. citizen)	18	33	50	0
	White (U.S. citizen)	458	46	41	11
	Underrepresented minority (U.S. citizen)	23	57	22	22
Life sciences	All	8,077	47	32	12
	U.S. citizen	5,032	42	39	15
	Foreign	2,539	65	23	8
	Male (U.S. citizen)	2,589	37	41	18
	Female (U.S. citizen)	2,443	47	37	12
	Asian/Pacific Islander (U.S. citizen)	314	50	30	13
	White (U.S. citizen)	4,234	42	40	15
	Underrepresented minority (U.S. citizen)	351	29	46	22
Psychology	All	3,489	25	28	32
	U.S. citizen	2,886	26	32	37
	Foreign	217	53	28	18
	Male (U.S. citizen)	944	23	30	42
	Female (U.S. citizen)	1,942	28	32	35
	Asian/Pacific Islander (U.S. citizen)	101	31	24	39
	White (U.S. citizen)	2,422	27	32	37
	Underrepresented minority (U.S. citizen)	319	19	34	40
Social sciences	All	4,049	40	32	19
	U.S. citizen	2,517	34	37	25
	Foreign	1,209	58	27	11
	Male (U.S. citizen)	1,399	32	39	24
	Female (U.S. citizen)	1,118	37	35	25
	Asian/Pacific Islander (U.S. citizen)	94	33	36	19
	White (U.S. citizen)	2,106	36	37	24
	Underrepresented minority (U.S. citizen)	222	22	44	33
Engineering	All	6,052	57	25	10
	U.S. citizen	2,688	50	34	11
	Foreign	2,989	68	20	10
	Male (U.S. citizen)	2,278	49	33	12
	Female (U.S. citizen)	410	51	37	9
	Asian/Pacific Islander (U.S. citizen)	285	45	32	12
	White (U.S. citizen)	2,126	51	34	11
	Underrepresented minority (U.S. citizen)	175	42	36	17

NOTES: Percentages do not total to 100 due to rounding and omission of nonrespondents from table. Underrepresented minorities include American Indians/Alaskan Natives, blacks, and Hispanics. Debt is for undergraduate and/or graduate education expenses for tuition and fees, living expenses and supplies, and transportation to and from school.

SOURCE: National Science Foundation, Division of Science Resources Studies, Survey of Earned Doctorates, various years, special tabulations.